Ref # 79

554

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY

FOREST INSECT INVESTIGATIONS

PROGRESS REPORT

ON THE EFFECTIVENESS OF THE PEELING METHOD OF CONTROL RELATIVE TO THE DESTRUCTION OF DENDROCTONUS BROODS IN WHITE PINE

By
Henry J. Rust
Senior Scientific Aid

Forest Insect Field Station
Coeur d'Alene, Idaho
January 22, 1930

U. S. GOVERNMENT PRINTING OFFICE: 1928 J 76133

PROGRESS REPORT ON THE EFFECTIVENESS OF THE PEELING METHOD OF CONTROL RELATIVE TO THE DESTRUCTION OF DENDROCTONUS BROODS IN WHITE PINE

Contents

	Page
INTRODUCTION	1
SCOPE	2
CAGED EXPERIMENTS	2
Summary of Caged Dendroctonus Brood Experiment	3
Larval Cage	3
Pupal Cage	4
New Adult Cage	5
Experimental Cages Constructed Around Base of Standing Green White Pine-	5
SURVIVAL PLOTS	7
BIOLOGICAL FACTORS RESPONSIBLE FOR DESTRUCTION OF DENDROCTONUS MONTICOLAE BROODS	8
Small Mammals	10
SUMMARY	26
ILLUSTRATIONS	
MAP	

PROGRESS REPORT ON THE EFFECTIVENESS OF THE PEELING METHOD OF CONTROL RELATIVE TO THE DESTRUCTION OF DENDROCTONUS BROODS IN WHITE PINE

INTRODUCTION

The year 1905 marked the institution of the first barkbeetle control project in the United States. This project was in the vicinity of Colorado Springs and Palmer Lake, Colorado, and the method of treatment used was felling the trees and peeling the infested portion of the bole.

The success of this method was based on the theory that the liberation of the immature Dendroctonus broods from their normal environment and exposure to the weather as an effect of peeling the bark would soon result in their destruction. This assumption seemed reasonably sound, and remained unquestioned until a few years ago when it was found that immature Dendroctonus broods when released by peeling infested trees could probably reach maturity if protected from predators.

During the summer of 1928 an experiment on the effectiveness of the peeling method of control relative to the destruction of Dendroctonus broods was conducted by the writer in an area heavily infested with the mountain pine beetle. This was in lodgepole pine on the Bitterroot National Forest near Sula, Montana.* As both lodgepole and white pine

* "Preliminary Report on the Effectiveness of the Peeling Method of Control Relative to the Destruction of Dendroctonus Broods" By H. J. Rust, Senior Scientific Aid.

are subject to serious infestations by the mountain pine beetle it was planned to institute the experiment on the effectiveness of the peeling method with both species of pine.

A mountain pine beetle control project in white pine on the Steamboat Creek drainage, Coeur d'Alene National Forest, was started in May, 1929. As the peeling method of control was to be used on this operation this was considered a very good area and opportunity to test the effectiveness of the method in white pine. This project was assigned to the writer and conducted during the months of May and June, 1929.

SCOPE

The experimental work in connection with this project in white pine, as with lodgepole pine, was divided into two parts: (1) to determine the possibility of Dendroctonus monticolae broods attaining maturity when released from their host by the peeling method of control and allowed to remain on the ground but protected from all predators; and (2) to determine the disposal of Dendroctonus broods when liberated from their host by the peeling method of control and permitted to remain on the forest floor subject to weather conditions and predators.

CAGED EXPERIMENTS

For the first part of the experiment three cages were constructed, the material for these being transported to the area and assembled as needed. The completed cages measured two feet square and 18 inches deep, and consisted of a light framework of wood covered with a closely-woven wire screen.

The site selected for the caged experiment was among a group of white pine infested by the mountain pine beetle on a steep east-facing slope (Figure 1). A portion of the hillside was dug away forming a level place large enough to accommodate the three cages (Figure 2). Enough duff to cover the floor of the cages was taken from the selected area and roasted over a fire to kill any predatory insect life that might be present. The results of the caged experiments are given in the following summary.

Summary of Caged Dendroctonus Brood Experiment

Larval Cage

May 16-27 — Between these dates 750 D. monticolae larvae were dropped on duff in the cage. A glass-rod type of thermometer was placed in the duff for recording temperatures, which are shown in the appended table.

June 3 — A few square inches of the duff were examined and one active pupa was seen. Owing to incessant rains, lack of sunshine and sufficient ventilation, the duff in the cage was becoming very wet and moldy.

June 5 — Two hundred and fifty additional larvae were placed on duff in the cage, bringing up the total to 1,000.

June 13 — Three active pupae were seen in a small section of the duff.

June 19 — After the cessation of a 48-hour rain storm the entire duff in the cage was examined. Twelve dead larvae and two active pupae were all that could be found of the D. monticolae brood. The duff was removed and dried over fire.

June 21 — Duff was replaced in the cage and 200 active D. monticolae larvae were placed on duff. At this time the cage was raised a couple of inches from the ground and supported in this position by a small flat stone at each corner. It was found that this method gave additional ventilation and helped prevent the accumulation of mold.

June 27 — On examining the cage on this date it was found that a number of small ants (Lasius niger var. americana) had gained entrance and were placing a number of the D. monticolae larvae in a pile under the duff in one corner. In disturbing a portion of the duff where the ants were working, 16 active pupae were disclosed. All the ants that were visible were destroyed in the hope that no more would enter the cage. A small section of freshly-cut white pine 2 feet long and 6 inches in diameter was placed in the cage to determine if any of the brood would survive, reach maturity, and attack.

Sept. 30. — Owing to absence from the area the final examination was not made until September 30 at which time the section of white pine was removed and examined for attacks. None were found. The duff was in good condition and it is believed that the entire brood was destroyed by the ants.

Pupal Cage

May 31 — No D. monticolae pupae were available until the last of May, at which time 150 were placed on duff in the cage.

June 5 — Twenty-five additional pupae were placed in the cage. The former placing appeared to be active and normal, although the duff was very wet and cold.

June 19 — The duff in the cage was examined at this time and it was found that all the pupae had perished, owing to the cold, wet, and moldy surroundings. The duff was removed and dried over a fire.

June 21 — The duff was replaced in the cage and 100 active pupae were added. The cage was raised two inches from the ground as was the larval cage.

June 27 — A small section of freshly-cut white pine was placed in the cage at this time to determine if any of the pupae reaching maturity would attack under caged conditions.

Sept. 30 — Final examination of the cage was made at this time. No attacks were found on the section of white pine and it is not known what became of the pupae unless they were destroyed by the same species of ants that entered the larval cage.

New Adult Cage

June 26 — Three hundred new adults were placed on duff in the cage at this time. This cage was raised from the ground for additional ventilation as with those containing larvae and pupae.

June 27 — A small section of freshly-cut white pine 2 feet long and 6 inches in diameter was placed in the cage on this date to determine if new adults released before normal emergence would successfully attack.

Sept. 30 — The final examination of the cage was made at this time. There were 26 attacks counted on the section of white pine that had been placed in the cage. Seven of the egg galleries were 12 inches long and the broods, while below normal in number, probably owing to the crowded condition, consisted of 85 per cent new adults, 10 per cent pupae, and 5 per cent larvae.

Experimental Cages Constructed Around the Base of Standing Green White Pine

June 6 — A wire screen cage was constructed around the base of a green white pine, 8 inches D.B.H. (Figure 3). Owing to the steepness of the slope the soil and duff on the lower side of the tree was raised to a level with the upper side, making an even floor for the cage. The lower edge of the wire screen was embedded in a trench and no screen was used for floor covering. Two hundred and fifty D. monticolae larvae and 10 pupae were placed on duff in the cage.

June 21 — Another small standing green white pine was caged on this date, constructed similarly to the first one. One hundred D. monticolae larvae and 100 pupae were placed on duff in the cage.

Sept. 30 — Owing to absence from the area the final examination of these two cages was not made until September 30. The screen was removed from the trees but no attacks were found. The duff was in good condition and it is believed that the D. monticolae broods were destroyed by small ants (Lasius niger var. americana), the only species found in the vicinity of the caged experiments.

Table 1

Temperatures of Duff in Dendroctonus monticolae Larval Cage at Various Dates and Time of Day

1929	Date	Time of Day	Temp. F.
	May 17	7.30 a.m.	41°
	" 17	12.00	49°
	" 17	4.30 p.m.	49°
	" 20	1.00 p.m.	52°
	" 21	7.30 a.m.	46°
	" 22	1.30 p.m.	57°
	" 23	8.00 a.m.	50°
	" 26	7.35 a.m.	40°
	" 27	10.00 a.m.	47°
	" 31	11.00 a.m.	52°
	June 5	12.30 p.m.	57°
	" 20	10.30 a.m.	46°
	" 22	12.30 p.m.	56°
	" 25	8.00 a.m.	58°
	" 26	10.30 a.m.	61°

Owing to frequent cold rains, hailstorms, lack of sunshine, and insufficient ventilation, the temperature of duff in the cages during May and early June was so low as to greatly retard the development of the confined D. monticolae broods. The broods released by the peeling method and covered with bark strips were subjected to the same low temperatures and amount of rainfall, but the duff having a good circulation of air the extreme moldy condition was not present and the mortality from exposure was very light as compared with the conditions in the larvae and pupal cages.

SURVIVAL PLOTS

The second phase of the experiment consisted in the establishment of 14 plots for making observations as to the mortality of D. monticolae broods released by the peeling method. These plots were placed so as to represent the various types of ground cover and duff of all exposures, as well as altitudes ranging from 3,100 to 4,100 feet. Eight of these plots averaging 1 foot wide by 16 feet long were placed alongside or, when possible, under, felled and peeled infested white pine trees. The released brood as they fell to the ground and were covered by pieces of bark removed by the peeling spuds, were used for observations as to their survival. On five of these plots an additional known number of D. monticolae brood was placed under marked pieces of bark and kept under close observation. The duration of these plots continued until no D. monticolae brood could be found between or under bark strips or in the duff. The remaining six plots were placed at varying distances from peeled logs, ranging from 1 foot to 150 yards. These plots averaged in size 1 foot wide by 16 feet long, and each one was divided into a number of sub-plots. Each sub-plot contained a known number of D. monticolae brood and was marked by a small stake so as to be readily located. The placing of these plots at varying distances from treated trees was to secure some idea of how thoroughly ants or rodents search for food, and if small pieces of bark placed over the sub-plots acted as an attraction.

BIOLOGICAL FACTORS RESPONSIBLE FOR THE DESTRUCTION OF DENDROCTONUS MONTICOLAE BROODS

In conducting the survival experiment with infested lodgepole pine on the Bitterroot National Forest in 1928 it was found that various species of ants were the only known factor in the removal or destruction of the D. monticolae broods placed on the plots on all but the north exposure. The ants named in order of their importance being Formica fusca L. var. subsericea Emery, Formica rufa asserans Wheeler, Leptothorax sp., Tapinoma sessile Say, and Lasius niger americanus Em.

On the north-facing slopes the duff consisted of a deep covering of moss which appeared to be shunned by the ants. A small species of centipede was common in the lower layer of this duff and, judging from caged experiments on this exposure, the centipedes were considered responsible for the destruction of the released D. monticolae broods. On the east, south, and west exposures, ant activity began shortly after placing the mountain pine beetle brood on the plots, and continued in many cases until the entire brood was either carried away by the larger ants or assembled in a pile on the soil under the duff by the smaller species with the possible idea of moving the colony near the abundant food supply.

An entirely different condition was encountered on the steep, heavily-timbered and brushy area in the white pine region of the Coeur d'Alene National Forest in 1929. The average duff was found to consist

of a layer of white pine needles varying from one-half to one and one-half inches deep, intermingled with dead and decaying leaves of the various species of shrubs and perennial plants growing on the different exposures. This layer of duff rested on a shallow covering of soil over a broken shaly rock formation, the soil remaining cold and damp until well along in June. No ant mounds or nests made of pine needles were found on the area when the control operations were conducted. A large carpenter ant (Camponotus herculeanus var. pennsylvanicus Forel.) which establishes colonies in decaying trees, stumps, and logs, was very abundant from the middle of May until the latter part of June, but was not found to be of any importance in the disposal of the monticolae broods. Lasius niger var. americana Em., a small ground-inhabiting variety, was the only ant that was found working on the plots. While their assistance in disposing of the broods released by the peeling method was valuable, they could not be considered of any great importance owing to their lack of numbers and limited distribution.

Destruction of the monticolae broods released by the peeling method in the white pine area was found to be largely the work of small rodents. When the first survival plots were established they were kept under observation for hours at a time during the day, but with little results. As soon as the large number of mountain pine beetle broods released from the peeled trees and the additional brood placed under marked pieces of bark began to rapidly disappear, in many instances overnight, evidence of small rodents was discovered, and it was decided to try trapping as a means of discovering the kinds and abundance of the small mammals working on the plots after nightfall.

Small Mammals

The results of trapping on the plots disclosed the fact that two species of mice, one species of vole, one of chipmunk, and one of shrew, were removing the broods from between and under pieces of bark, from the duff on the marked plots, and from the entire area of the control operation. A small series of these mammals were trapped alive and confined in cages for close observation as to their method of securing monticolae larvae and pupae from duff under the pieces of bark, and as to the amount they would consume as food in known periods of time.

The activities of these mammals in confinement are given in separate tables following a brief description of the fourteen marked plots under observation.

Table 2

Tabulated Description of Eight Survival Plots Under Observation

Plot Symbol	Date Established	Location of Plots	Size of Plot	Exposure	Elevation feet	Duff Pine Needles	Ground Cover
A	May 22	By peeled log near creek	1'x16'	W	3100	1½" deep	Small plants
B	May 23	By peeled log on steep slope	1'x16'	E	3200	1½" deep	Brushy
C	May 27	By peeled log on steep slope	1'x16'	E	3200	1½" deep	Brushy
E	June 1	By peeled log near creek	1'x16'	E	3150	1½" deep	Brushy
J	June 14	By peeled log on high ridge	1'x16'	W	4100	1" deep	Small plants
K	June 14	By peeled log on high ridge	1'x32'	W	4100	1½" deep	Small plants
M	June 22	Under peeled log in ravine	1'x32'	S	3150	1" deep	Brushy
N	June 22	Under peeled log on steep slope	1'x32'	S	3150	1" deep	Brushy

Table 3

Mountain Pine Beetle Brood Used on Eight Plots
Duration of Plots and Predatory Agents Responsible for Destruction of Larvae and Pupae

Plot Symbol	Estimated No. of Mountain Pine Beetle Released	No. of Mountain Pine Beetle Brood Added	Duration of Plot	Predatory Agents Responsible for Disposal of Mountain Pine Beetle Broods
A	4000	1200	6 days	Small mammals
B	2400	1000	7 "	Ants and small mammals
C	2000	300	5 "	Ants and small mammals
E	4800	500	3 "	Small mammals
J	3040	--	8 "	Small mammals
K	9600	500	12 "	Small mammals
M	9000	--	10 "	Ants and small mammals
N	6200	--	12 "	Small mammals

The eight plots as shown in Tables 2 and 3 were placed in various situations during an interval of a month (May 22 to June 22) and at elevations ranging from 3100 to 4100 feet, and included all but the north exposure. The estimated number of released D. monticolae brood on the plots varied from 2,000 to 9,600, the average being 5,130. Prior to May 31 the released broods consisted entirely of larvae. After the first of June pupae began to appear and by June 22 comprised approximately 75 per cent of the released broods. Additional mountain pine beetle broods were placed on five of the plots both to increase the number present to test out the ability of predatory agents, and to give a definite number to keep under daily observation. The duration of the plots varied from three to twelve days, with an average of 7.7 days. Trapping for small mammals was conducted on these plots and the results are given in a separate table. Lasius niger var. americana, a small ground-inhabiting variety of ant, was observed on three of the plots. They were not seen carrying any of the D. monticolae larvae or pupae away from the plots but instead they placed the brood in a pile on the soil under the piece of bark where they were found working. In their efforts to move the larvae or pupae they apparently punctured the skin with their sharp mandibles as all the brood placed in piles by the ants appeared to be dead. When the small mammals would appear on the plots where the ants had been working the entire pile of mountain pine beetle larvae or pupae would disappear and the ants would no longer be seen where their food supply was removed. In addition to these eight marked plots similar observations were made throughout the area where control operations were conducted, to check up on the effectiveness of small rodents disposing of the brood. In no instance were D. monticolae larvae, pupae, or new adults found under the removed bark strips or in the duff after a period of twelve days from the time of treating.

Table 4

Tabulated Description of Six Survival Plots Containing Sub-plots Under Observation

Plot Symbol	No. of Sub-plots	Date Established	Sub-plots Covered with Bark	Location of Plots	Size of Plot Area	Exposure	Elevation	Duff	Ground Cover
D	5	5/27	All	150 yds. from treated logs	1'x5'	W	3250	1½" deep	Brushy
F	20	6/5	"	At group of treated logs	1'x16'	W	3100	1½" "	Small plants
G	20	6/8	"	By peeled white pine logs	1'x16'	E	3150	1½" "	Brushy
H	20	6/13	"	" " " " "	1'x16'	W	3200	1" "	Small plants
I	20	6/13	Two	20 ft. from treated logs	1'x16'	W	3200	1" "	" "
L	20	6/14	None	50 " " " "	2'x20'	S	4100	1½" "	Brushy

Table 5

Number of Mountain Pine Beetle Brood Used on Six Plots Containing Sub-plots
Duration of Plots and Predatory Agents Responsible for Destruction of Larvae and Pupae

Plot Symbol	No. of Sub-Plots	No. of M.P.B. Brood on Sub-plots	Total No. on Plot	Disposal of Mountain Pine Beetle Broods and Total Duration of Plots	Predatory Agents Responsible for Destruction of Mountain Pine Beetle Broods
D	5	100	500	100% in 8 days	Small shrew
F	20	10	200	98% in 9 days; 100% " 11 "	Small rodents
G	20	10	200	99% in 6 " ; 100% " 8 "	Small shrew
H	20	10	200	99% in 6 " ; 100% " 9 "	Small rodents
I	20	10	200	96% in 6 " ; 100% " 8 "	Small rodents
L	20	10	200	98% in 9 " ; 100% " 12 "	Centipedes and shrews

These six plots, each containing a number of sub-plots, were established at distances varying from one foot to 150 yards from peeled white pine logs during an interval of 19 days and at elevations varying from 2900 to 3900 feet. The plots near treated logs were placed where the released mountain pine beetle broods had been removed by predatory agents some time previously. The object of the plots was to find out, if possible, if small rodents are attracted to logs lying on the ground as a possible source of food, how long and thoroughly they search for food in a certain area, and if pieces of bark lying on the ground would act as an added attraction. Three of the plots were placed near treated logs and three some distance away, one being 20 feet, one 50 feet, and one 150 yards from the nearest peeled logs. The sub-plots on those near logs were covered with pieces of bark that had been removed from the treated logs. On Plot I only two of the sub-plots were covered with bark, and on Plot L no bark was used. In placing Plots I and L a small portion of the duff was carefully pushed to one side, the monticolae brood placed on the soil and the duff replaced to show as little disturbance as possible.

The average duration of the plots at treated logs was 8.3 days, of those at varying distances, 10.3 days.

In locating white pine trees attacked by the mountain pine beetle on the Steamboat Creek drainage it was found that 33 per cent of the infestation on four sections was situated on steep slopes. After peeling the upper portion of the logs from many of these trees and in attempting to turn them over to treat the under side, the logs would slide down the steep slope and the peeling would be completed some distance from where the tree was felled.

In instances of this kind the mountain pine beetle broods released from the upper portion of the logs would be left lying on the ground partially or entirely covered with bits or strips of bark. Three of the plots, D, I, and L, were used to supplement observations made on this phase of the peeling method.

Table 6

Distribution and Abundance of Small Mammals on the Steamboat Creek Control Project as Determined by Trapping on the Marked Plots Under Observation

Plot Symbol	Elevation	No. of Traps	Kind of Traps	Duration of Set	Catch	Date
A	3100	2	Box traps	5/27-6/3	2 wood mice, young	5/28
		2	" "	5/27-6/3	1 " " adult	5/30
		3	" "	6/4-6/7	3 " " "	6/5
					1 Rocky Mt. Jumping Mouse	6/7
D 5 sub-plots	3250	2	Box traps	6/6-6/13		
E	3150	2	Snap traps	6/1-6/3	2 small shrews	6/2
		2	" "	6/1-6/3	2 Rocky Mt. Jumping Mice	6/3
		2	Box traps	6/3-6/4	1 chipmunk and 1 small shrew	6/4
H 20 sub-" plots	3200	2	Box traps	6/4-6/13		
K	4100	1	Box traps	6/14-6/25	1 Wood mouse, adult	6/22
		2	Snap "	6/14-6/25	1 " " "	6/25
L 20 sub-plots	4100	2	Snap traps	6/14-6/25		
M	3150	2	Box traps	6/20-6/26	1 Vole	6/21
		2	Snap "	6/22-6/26	1 Wood mouse	6/23
					1 Roky.Mt.Jump.Mouse	6/26
					1 Vole	6/26
N	3150	1	Snap trap	6/22-6/26	1 Vole, young	6/23

Table 7

Distribution and Abundance of Small Mammals on the Stemhont Creek Control Project as Determined by Trapping at Groups of Treated Trees over Extensive Area

Group No.	Elevation	No. of Treated Trees	No. of Traps	Kind of Traps	Duration of Set	Catch
1	3150	3	3	Snap	6/26-6/27	1 Wood mouse and 1 Vole, young
2	3150	3	5	Snap	24 hours	1 Wood mouse, young
3	3200	1	1	Snap		
4	3250	2	2	Snap		
5	3400	1	3	Snap		1 Wood mouse
6	3700	3	3	Snap		

A summary of the results of trapping small mammals on the control area as given in Tables 6 and 7 shows that the greatest number and variety were caught on plots placed alongside peeled logs in groups of treated trees. No mammals were caught on Plots D, K, and L. Plot D contained five sub-plots and was placed 150 yards from the nearest treated trees, and Plot L with 20 sub-plots 50 yards away. A small shrew was observed a few feet from Plot D on the date that the entire D. monticolae broods were missing from the plot, but none entered the type of trap set on this plot. A number of the snap traps set on the various plots were often found sprung and with the bait removed. It is believed that the small shrews (Sorex cinereus cinereus) inhabiting the area were responsible, they being the most difficult mammals to secure with the types of traps used on the plots.

Table 8

Chipmunk (Eutamias ruficaudus simulans) Captured on Plot E and Placed in Cage for Feeding Experiment, June 3

Date	No. of M.P.B. Brood for Food	Time of Placing Food in Cage	Time Required to Consume M.P.B. Brood	Other Kinds of Food Eaten by Chipmunk
6/3	100 larvae and pupae mixed	2.00 p.m.	During night of June 3 (food under bark)	None supplied
6/4	100 larvae and pupae mixed	7.30 p.m.	2 minutes by watch (food under bark)	None supplied
6/4	50 larvae and pupae mixed	7.45 a.m.	47 eaten in 70 seconds 3 overlooked in duff	None supplied

6/4 chipmunk liberated 10.00 a.m.

Table 9

Chipmunk (Eutamias ruficaudus simulans) Captured Alive And Placed in Cage for Feeding Experiment, 7.45 a.m., June 17

Date	No. of M.P.B. Brood for Food	Time of Placing Food in Cage	Time Required to Consume M.P.B. Brood	Other Kinds of Food Eaten by Chipmunk
6/17	200 larvae and pupae mixed	8.15 a.m.	8.40 chipmunk began feeding on brood, ate about half of number and stopped, returning later. 195 eaten by 10.15 a.m. All consumed at 5 p.m.	Small quantity of Rolled Oats
6/17	100 larvae and pupae mixed	5.00 p.m.	All eaten during night of 17th	Small quantity of Rolled Oats
6/18	200 larvae and pupae mixed	7.15 a.m.	62 of brood eaten during day, balance during night of 18th	Small quantity of Rolled Oats
6/19	100 larvae and pupae mixed	6.10 a.m.	78 of brood eaten by 1 pm All damaged pupae left untouched	Small quantity of Rolled Oats
6/19	100 larvae and pupae mixed	1.00 p.m.	Eaten in 60 minutes	Small quantity of Rolled Oats
6/19	100 larvae and pupae mixed	5.00 p.m.	All eaten during night of 19th	Small quantity of Rolled Oats
6/20	200 larvae and pupae mixed	9.00 a.m.	Consumed during period 9 a.m. 20th to 8 a.m. 21st	Small quantity of Rolled Oats

Total 1,000 - Average per day 250.

6/21 Chipmunk liberated at 8.00 a.m.

Shrew (Sorex cinereus cinereus)
Captured Alive on Plot E, June 4, in Box Trap.

A shrew of this species was captured alive on Plot E and was liberated in a cage two feet square and 18 inches deep, covered with close-woven wire screen. The floor of the cage was covered with a layer of duff consisting of pine needles and decaying vegetation as found throughout the white pine area. In one corner of the cage a small portion of the duff was removed and 500 monticolae larvae and pupae mixed were placed on the floor and the duff replaced (Figure 18). A small piece of white pine bark was laid on top of the duff to resemble conditions similar to survival plots under observation. The shrew was placed in the cage at 3.30 p.m. on June 4. An examination made at 7 a.m., June 5, of the duff under the bark disclosed the fact that all of the monticolae brood had been taken during the night. A photograph was made showing the small holes in the duff made by the shrew (Figure 19). The shrew was also observed tunneling through the duff. This was accomplished with apparent ease and the rapid movements were followed by a slight movement of the duff. An additional 500 larvae and pupae mixed were placed under the duff and covered with the piece of bark as before. The shrew was very active during the early part of the day. Observations were discontinued from 3.30 p.m. until 5.00 p.m., at which time the shrew was found lying dead on the floor of the cage. Only 50 of the monticolae brood had been taken during the day.

Female Wood Mouse (Peromyscus maniculatus artemisiae) with Five Young Adult female captured alive on Plot A, night of June 6

On June 6 two female wood mice were found in box traps set on Plot A. They were liberated in screen cage at 11.00 a.m. Four hundred and fifty P. maniculatus larvae and pupae mixed had been placed under a small piece of bark on the floor of the cage prior to the entrance of the mice. The two mice when placed in the cage appeared to resent each other's presence and acted as if fighting. Observations were discontinued until 12.30 p.m., at which time quiet reigned in the cage. The adult mice were not in sight and on raising the small piece of bark covering the P. maniculatus brood it was found that five young mice had been born and that both adults were trying to cover the young from sight. They had scooped out a nest cavity in the pine needles under the bark, the bottom of the nest resting on the screen floor of the cage. The bark covering was just large enough to shelter the temporary nest. These mice were fed exclusively on rolled oats and bread crusts until changed to other cages on June 25. When the bark covering was raised for examination on June 24 one of the adult mice left the nest and took shelter under a smaller piece of bark lying on the bottom of the cage, the other remaining with the five young which had grown to such a size as to completely crowd the nest capacity. On June 25 the female mouse that had remained in the nest, and the five young mice, were transferred to a smaller cage. At the same time the

Adult female orphaned albino on Plot A, night of June 6
Female Wood Mouse (*Peromyscus maniculatus arctenicolae*) with five young

On June 6 two female wood mice were found in box traps set on Plot A. They were librated in screen cage at 11:00 a.m. Both inspired and fifty B. Monticello leaves and jungle mixed had been placed under a small piece of bark on the floor of the cage prior to the entrance of the mice. The two mice when placed in the cage appeared to resent each other's presence and acted as if fighting. Observations were discontinued until 12:30 p.m., at which time quite relaxed in the cage. The adult mice were not in sight and on raising the small piece of bark covering the B. monticolae found it was found that five young mice had been born and that both adults were trying to cover the young from sight. They had escaped out a neat cavity in the pine needles under the bark. The position of the nest resting on the screen floor of the cage. The bark covering was just large enough to shelter the temporary nest. These mice were fed exclusively on rolled oats and bread crusts until cleaned to other cages on June 25. When the bark covering was raised for examination on June 9th one of the adult mice left the nest and took shelter under a smaller piece of bark lying on the bottom of the cage, the other remaining with the five young which had grown to such a size as to completely crowd the nest cavity.

On June 25 the female mouse that remained in the nest, and the five young mice, were transferred to a smaller cage. At the same time the

female that remained in hiding under the small piece of bark was removed to another cage. On June 25 at 1.00 p.m., 1,000 D. monticolae larvae and pupae mixed were placed in a pile on the cage floor occupied by the female and five young. This was the first insect food fed with the exception of the 450 larvae and pupae mixed that were in the duff on the bottom of the cage in which the mice were first placed on June 6. At 6.30 p.m. one young mouse came out from the next box and began feeding on the monticolae brood, and by 8.30 p.m. all of the five young were observed feeding on the larvae and pupae. All of the remaining monticolae brood were consumed during the night of June 25, as well as a small quantity of rolled oats and bread crusts. On June 26 at 11.30 a.m. 1,500 monticolae larvae and pupae mixed and 55 new adults, making a total of 1,555, were placed on the floor of the cage. At 11.45 a.m. two of the young mice were observed feeding on the brood. No remains of any of the larvae, pupae, or new adults were found in the cage on the morning of June 27. On June 28 the mice were liberated, owing to the termination of the survival experiment in the Steamboat Creek drainage.

Table 10

Wood Mouse (*Peromyscus maniculatus artemisia*) Rhodes
Captured Alive and Placed in Cage for Feeding Experiment, 8.30 a.m. June 16

Date	No. of M.P.B. Brood for Food	Time of Placing Food in Cage	Time Required to Consume M.P.B. Brood	Other Kinds of Food Eaten by Mouse
6/16	100 larvae	8.30 a.m.	6 min. by watch	
6/16	100 "	9.00 a.m.	15 " " "	
6/16	100 "	1.30 p.m.	10 " " "	
6/16	100 "	6.00 p.m.	Eaten during night of June 16	
6/17	150 larvae and pupae mixed	7.20 a.m.	143 in 20 min., balance of 7 by 9.30 am	Small quantity of rolled oats
6/17	50 larvae and pupae mixed	12.00 noon	10 min. by watch	
6/17	150 larvae and pupae mixed	4.30 p.m.	18 min. by watch	Small quantity of rolled oats
6/18	200 larvae and pupae mixed	6.55 a.m.	179 eaten in 15 min. balance of 21. later	
6/18	50 larvae and pupae mixed	11.48 a.m.	2 min. by watch, searching for more	
6/18	200 larvae and pupae mixed	7.25 p.m.	11 min. by watch	
6/19	200 larvae and pupae mixed	6.15 a.m.	192 in 14 min., balance of 8 eaten by 7.30 a.m.	
6/19	100 larvae and pupae mixed	10.20 a.m.	4 min. by watch	
6/19	15 new adults	1.00 p.m.	3 min. by watch; required longer time to eat adult beetles	
6/19	190 larvae and pupae mixed: 10 new adults	4.40 p.m.	10 min. by watch	
6/20	200 larvae and pupae mixed	6.00 a.m.	8 min. by watch	
6/20	200 larvae and pupae mixed	11.00 a.m.	6 min. by watch	Small quantity of rolled oats
6/20	200 larvae and pupae mixed	5.00 p.m.	6 min. by watch	
6/21	250 larvae and pupae mixed	7.22 a.m.	10 min. by watch	Small quantity of rolled oats
6/21	250 larvae and pupae mixed	1.07 p.m.	7 min. by watch	
6/21	250 larvae and pupae mixed	4.35 p.m.	200 eaten in 15 min. balance during night	
6/22	333 larvae and pupae mixed	8.25 a.m.	8½ min. by watch	8 flakes of rolled oats
6/22	517 larvae and pupae mixed	7.00 p.m.	395 in 9 min., bal. of 122 eaten during night	Small quantity of rolled oats
6/23-25	—	—	—	Rolled oats and bread crust

Total 3,915. Average per day for 7 days, 559. Maximum for 11 hours feeding during day apparently reached on June 22 when 725 larvae and pupae mixed were consumed. Mouse was liberated on June 25, apparently in good condition.

Table 10

Wood blocks (*Xestobium mediolubrum* nr *rufovillosa*) Ifrane
Captured Alive and Placed in Cage for Feeding Experiment, 8.30 a.m. June 16

Date	No. of M.F.B. Placed for Food in Cage	Size of M.F.B. Required for Capture	Other Kinds of Food Taken by Them
6/16	100 Larvae	8.30 a.m.	6 min. by watch
6/16	100 "	9.00 a.m.	12 " " "
6/16	100 "	1.30 p.m.	10 " " "
6/16	100 "	5.00 p.m.	Eaten during night
			of June 16
6/17	150 Larvae and Pupae mixed	7.30 a.m.	195 in 30 min., but quantity of rolled oats
6/17	50 Larvae and Pupae mixed	12.00 noon	10 min. by watch
6/17	150 Larvae and Pupae mixed	4.30 p.m.	18 min. by watch
6/18	200 Larvae and Pupae mixed	6.55 a.m.	175 eaten in 15 min. Balance of 25, Inferior
6/18	50 Larvae and Pupae mixed	11.00 a.m.	2 min. by watch,
6/18	200 Larvae and Pupae mixed	1.25 p.m.	11 min. by watch
6/19	200 Larvae and Pupae mixed	6.15 a.m.	192 in 14 min., balance of 8 eaten by 10.30 a.m.
6/19	100 Larvae and Pupae mixed	10.20 a.m.	4 min. by watch
6/19	15 new adults	1.00 p.m.	5 min. by watch; remained longer time but not fully harden
6/19	150 Larvae and Pupae mixed	4.40 p.m.	10 min. by watch
6/20	200 Larvae and Pupae mixed	6.00 a.m.	8 min. by watch
6/20	200 Larvae and Pupae mixed	11.00 a.m.	6 min. by watch
6/20	200 Larvae and Pupae mixed	5.00 p.m.	6 min. by watch
6/21	250 Larvae and Pupae mixed	7.25 a.m.	10 min. by watch
6/21	250 Larvae and Pupae mixed	1.01 p.m.	7 min. by watch
6/21	250 Larvae and Pupae mixed	4.35 p.m.	200 eaten in 15 min. Balance during night
6/22	353 Larvae and Pupae mixed	8.25 a.m.	18 min. by watch
6/22	321 Larvae and Pupae mixed	1.00 p.m.	295 in 9 min., but qty. of rolled oats 158 eaten during night
6/23-25	—	—	Rolled oats and bread crust

Total 3,215. Average per day for 7 days, 459. Maximum for 11 hours feeding during day observed, 295 in 9 min. Larvae and pupae mixed were consumed. Adult was liberated on June 25, approximately 12 days after capture.

Table 11

Vole (Microtus mexicanus mexicanus)
Captured Alive Near Survival Plot A, June 21

Date	No. of M.P.B. Brood for Food	Time of Placing Food in the Cage	Time Required to Consume M.P.B. Brood	Other Kinds of Food Eaten
6/21	175 larvae and pupae mixed	8.00 a.m.	7/8 of brood eaten by 9.45 a.m.	Small quantity of rolled oats
6/21	100 larvae and pupae mixed	1.05 p.m.	All eaten by 3.30 p.m.	Small quantity of rolled oats
6/21	100 larvae and pupae mixed	4.35 p.m.	9/8 of brood eaten by 4.50 p.m.	Small quantity of rolled oats
6/22	150 larvae and pupae mixed	7.30 a.m.	1/3 of brood eaten by 8.00 a.m.	
6/22	200 larvae and pupae mixed	5.30 a.m.	All eaten during night of 22d	Small quantity of rolled oats
6/23	350 larvae and pupae mixed	8.00 a.m.	Eaten during day and night of 23rd	
6/24	350 larvae and pupae mixed	7.00 a.m.	Eaten during night of 24th	Small quantity of rolled oats
6/25	400 larvae and pupae mixed	11.30 a.m.	Eaten during night of 25th	Small quantity of rolled oats

Total 1,725 larvae and pupae mixed. Daily average for five days, 345. Vole was liberated on June 26, apparently in good condition.

Table 12

Rocky Mountain Jumping Mouse (Zapus princeps princeps) Allen
Captured on Plot A in Box Trap, Night of June 5

Date	No. of M.P.B. Brood for Food	Time of Placing Food in the Cage	Time Required to Consume M.P.B. Brood	Other Kinds of Food Eaten
6/5	50 larvae and pupae mixed	4.00 p.m.	Eaten during night of 5th	No other food supplied
6/6	100 larvae and pupae mixed	7.30 a.m.	Eaten during day of 6th	No other food supplied
6/7	Mouse found dead in nest on morning of 7th. May have died from starvation.			

Table 13

The Topographical Distribution and Per Cent of the Infested Trees on Sections 15, 22, 27 and 34

Section No.	Infested Trees Near Streams: No.	Per Cent	Infested Trees on Slopes: No.	Per Cent	Infested Trees on Ridges: No.	Per Cent	Total No. of Trees	Total Per Cent
15	138	44	115	37	60	19	313	100
22	113	50	69	31	42	19	224	100
27	61	49	49	39	15	12	125	100
34	64	57	20	18	28	25	112	100
Total	376	49	253	33	145	18	774	100

The topographical distribution of the infested trees would appear to have considerable bearing on the possibility of destruction of the broods by predatory agents, such as small mammals. Table 13 shows that on the four sections practically one half of the infested trees were found near streams, 33 per cent on steep slopes and 18 per cent on high ridges. From the results of observations made at the treated logs and trapping small mammals on the survival plots, it is believed that the greatest abundance of rodents is found in the vicinity of streams on the Steamboat Creek drainage.

Table 13

The Topographical Distribution and Per Cent of the Infested Trees on Sections 15, 22, 27 and 34

Section	Infested Trees Near Streams	Infested Trees on Slopes	Infested Trees on Ridges	Total No.	Per Cent of Infested Trees
	No.	Per Cent	No.	Per Cent	No.	Per Cent		
15	138	44	115	37	60	19	313	100
22	113	50	69	31	42	19	224	100
27	63	49	49	39	15	12	127	100
34	64	37	20	18	28	25	112	100
Total	378	44	253	31	145	18	776	100

The topographical distribution of the infested trees would appear to have considerable bearing on the possibility of destruction of the spruce by predatory agents, such as small mammals. Table 13 shows that on the four sections practically one half of the infested trees were found near streams, 33 per cent on steep slopes and 18 per cent on high ridges. From the results of observations made at the treated logs and trapping small mammals on the survival plots, it is believed that the greatest abundance of rodents is found in the vicinity of streams on the Steamboat Creek drainage.

Table 14

The Distribution and Per Cent of Infestation on Each Section by Acres

Section No.	Total Number of Acres	Number of Acres Containing Infestation	Per Cent	Number of Trees
15	640	144	22	313
22	640	88	14	224
27	640	78	12	125
34	640	98	15	112
Totals	2560	408	16	774

Average 1.9 trees per acre on area of concentration; 0.3 tree for total acreage.

In considering the possibility of small mammals disposing of all the monticolae broods released by the peeling method on a certain area the distribution per acre of the infested trees becomes a matter for consideration. A 100 per cent disposal of the released broods from the peeled trees on an acre basis would depend practically on the number and activity of small mammals when no ants are present, either inhabiting each acre or coming in from other areas in search of food. Table 14 shows that on the four sections used in this study only a very small per cent of the total number of acres contained infested trees. An average for the entire area would give only 0.3 of a tree per acre, while in reality there were 1.9, or practically two, trees per acre on 16 per cent of the area, while the balance, or 84 per cent, contained no infested trees. The final results of the observations on brood disposal on the controlled area showed that small mammals were abundant enough to dispose of all the released broods where there was an average of two infested trees on 16 per cent of the area.

Table 14

The Distribution and Per Cent of Infestation on
Each Section by Acres

Section No.	Total Number of Acres	Number of Acres Containing Infestation	Per Cent	Number of Trees
15	640	144	22	312
22	640	88	14	224
27	640	76	12	152
34	640	96	15	172
Totals	2560	404	16	124

Average 1.9 trees per acre on area of concentration; 0.3 trees for total acreage.

In considering the possibility of small mammals dispersing of all the poisoned grain released by the peeling method on a certain area the distribution per acre of the infested trees becomes a matter for consideration. A 100 per cent disposal of the released grain from the peeled trees on an acre basis would depend practically on the number and activity of small mammals when no mate are present, either interfering each more or coming in from other areas in search of food. Table 14 shows that on the four sections used in this study only a very small per cent of the total number of acres contained infested trees. An average for the entire area would give only 0.3 of a tree per acre, while in reality there were 1.9, or practically two, trees per acre on 16 per cent of the area, while the balance, or 84 per cent, contained no infested trees. The final results of the observations on grain disposal on the controlled area showed that small mammals were abundant enough to dispose of all the released grain where there was an average of two infested trees on 16 per cent of the area.

Table 15

Infested White Pine Trees on Sections 15, 22, 27, and 34, Arranged According to Groups and the Per Cent Each Group Represents of Entire Infestation on the Four Sections, Also the Total Number of Trees Infested.

Section No.	Number of Infested Trees Arranged in Groups														No. of Trees	Per Cent
	1	2	3	4	5	6	7	8	9	10	11	14	15	17		
15	60	35	16	9	3	7	--	--	--	1	--	--	1	1	313	40.4
22	36	20	6	9	6	1	1	--	1	--	1	1	--	1	224	29.0
27	37	19	8	1	2	2	--	--	--	--	--	--	--	--	125	16.1
34	42	9	1	2	2	--	2	1	1		--	--	--	--	112	14.5
Total Groups	175	83	31	21	13	10	3	1	2	1	1	1	1	2		
Total Trees	175	166	93	84	65	60	21	8	18	10	11	14	15	34	774	100.
Per Cent	23.0	21.5	12.0	10.8	8.3	7.8	2.7	1.0	2.3	1.2	1.4	1.8	1.9	4.3		100

Table 15

Industrial Wells by Three Types on Sections 15, 22, 27, and 34, Barrington Township by County and the 2nd Tenth Digit Depth Groups of Wells Accordingly. Also Shown are Sections, Also the Total Number of These Industrial.

| Section | Number of Industrial Wells Located in Groups | | |

It would be expected that the greatest possible chance of any released D. monticolae brood escaping predatory agents would come from large groups of treated trees. In considering the white pine trees attacked by the mountain pine beetle, arranged according to groups on the four heaviest infested sections of the Steamboat control area, Table 15 shows that nearly half of the infestation falls in groups of one or two trees. Twenty three per cent, or 175 trees, occurred as individual, and 21.5 per cent, or 166 trees, in 83 groups of two trees each.

This condition as found to exist throughout the control area for 1929 becomes an important factor in the disposal of the D. monticolae broods released by the peeling method of control.

SUMMARY

Caged Experiments

The results of the caged experiments in white pine during the season of 1929 were not very satisfactory. A long spell of rainy weather accompanied by low temperatures, and a lack of proper ventilation in the larval and pupal cages created a condition fatal to the Dendroctonus broods. A large per cent of the first placing of larvae transformed to the pupal stage but were destroyed by the wet and moldy condition of the duff. Of the later placings many larvae reached the pupal stage but were destroyed by a small species of ant

that had gained entrance into the cage. None of the pupae of the first placing reached the new adult stage; they all perished in the cold and moldy duff in their cage. At the final examination no evidence was found of the later placing of pupae reaching maturity. It is believed that they were destroyed by the small species of ant that was seen in the larval cage.

In the new adult cage it was found that the section of white pine contained 26 attacks. Seven of the egg galleries were 12 inches long and the broods consisted of 85 per cent new adults, 10 per cent pupae, and 5 per cent larvae at the date of the final examination, September 30, 1929.

None of the larvae or pupae placed in the cages constructed around the bases of the green standing white pine reached maturity and attacked the trees. It is thought that the broods were destroyed by ants.

Survival Plots

The results of observations made at the 14 survival plots and over the entire area of control showed that there was little possibility of any D. monticolae broods, released during the spring control operations, reaching maturity in the duff. Evidence of small rodents was found at all the treated trees.

From the results of the feeding experiments conducted with the small mammals captured on the plots it is believed that with the exception of the few larvae and pupae destroyed by the small ants the

balance of the broods were devoured by the mice, voles, chipmunks, and shrews, inhabiting the area.

Respectfully Submitted,

Henry J. Rust

Henry J. Rust
Senior Scientific Aid

January 22, 1930

Figure 1. View of steep brushy slope, east exposure, where cages for P. monticolae brood survival were placed. Exact location marked by circle.

Figure 2. Close up view showing the three cages used for the P. monticolae brood survival experiment. After digging away the hillside for a level place large enough to accommodate the three cages a bear used the unoccupied part of this level place for gnawing on bones secured from the control camp not far from the base of the slope. The method of fastening cages to a pole nailed to trees was to help prevent the cages from being rolled down the slope by the bear.

H.J.R.

Fig. 1

H.J.R.

Fig. 2

Figure 3. Wire screen cage constructed around the base of an uninfested green standing white pine. The duff remained in good condition in this cage but no attacks were secured from the D. monticolae broods placed in the cage, owing to the entrance of Lasius niger var. americana, a small species of ground-inhabiting ant.

H.J.R.

Fig. 3

Figure 4. View showing a group of 11 white pine trees infested by the mountain pine beetle. The infested trees have been examined by the spotting crew and marked with white tags for treating. Two of the trees have been felled; the untreated logs are seen lying on the ground. The tagged infested white pine at the right of the picture shows the beneficial work of woodpeckers in removing bark and securing the D. monticolae broods during the winter months. The heaviest infested portion of the tree is usually selected by the woodpeckers.

H.J.R.

Fig. 4

Figure 5. The treating crew working on group of infested white pine shown in Figure 4.

Figure 6. Group of infested white pine shown in Figures 4 and 5 after being peeled by treating crew. This group of treated logs was used extensively for observations as to the survival of the released D. monticolae broods and was the location of survival plots A and F.

H.J.R.

Fig. 5

H.J.R.

Fig. 6

Figure 7. View showing the peeling spud in use. With infested logs where the bark was tight a large per cent of the D. monticolae larvae and pupae were crushed by the peeling spud in removing the bark.

Figure 8. Bark removed from a portion of an infested log showing the D. monticolae larvae and pupae rolling out from their pupal cells and dropping to the ground. Many of the larvae and pupae escape crushing by the peeling spud on logs when the bark is partly loosened by being confined in deep pits constructed for pupal cells.

H.J.C.

Fig. 7

H.J.C.

Fig. 8

Figure 9. Infested groups of white pine growing on uneven ground. When felled for treating they often rest clear of the ground nearly the entire length. This usually permits large strips of bark being removed with no loss of brood by being crushed in rolling over the logs over. Groups of this kind offer the best possible chance for released D. monticolae broods maturing in the duff if undisturbed by predatory agents.

Figure 10. Close up view of peeled white pine trees resting clear of the ground for considerable length. This view also shows clusters of bark strips removed from the trees.

H.J.R.

Fig. 9

H.J.R.

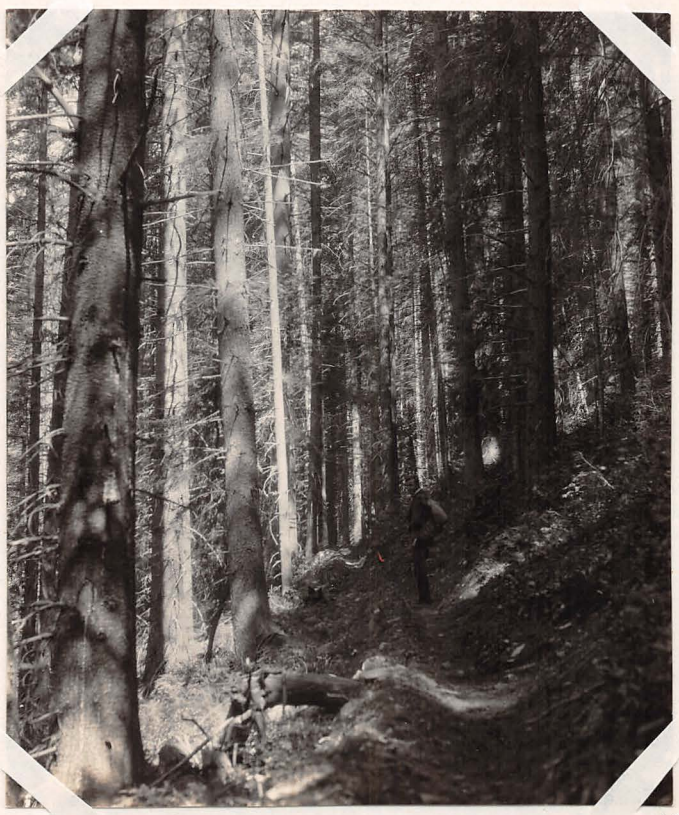
Fig. 10

Figure 11. View of stand of white pine on east-facing slope on the East Fork of Steamboat Creek.

Figure 12. Along the trail through the white pine, west-facing slope on East Fork of Steamboat Creek.

H.V.R.

Fig. 11



H.V.R.

Fig. 12

Small mammals benefited in destroying
D. *Hemidactylus* brooks released by the
Peering method.

Figure 13. Shrew (*Sorex ehrenbergi ehrenbergi*)†

Figure 14. Chipmunk (*Eutamias merriami minimus*)*

Figure 15. Wood mouse (*Peromyscus maniculatus arboreicus*)*

Figure 16. Rocky mountain jumping mouse (*Zapus trinotatus trinotatus*)*

Figure 17. Vole (*Microtus montanus montanus*)*

* Determinations by the Bureau of Biological Survey.
Washington, D. C.

Small mammals beneficial in destroying *D. monticolae* broods released by the peeling method.

Figure 13. Shrew (*Sorex cinereus cinereus*)†

Figure 14. Chipmunk (*Eutamias ruficaudus simulans*)*

Figure 15. Wood mouse (*Peromyscus maniculatus artemisiae*)*

Figure 16. Rocky mountain jumping mouse (*Zapus princeps princeps*)*

Figure 17. Vole (*Microtus mordax mordax*)*

* Determinations by the Bureau of Biological Survey, Washington, D. C.

Fig. 13

Fig. 14

Fig. 15

Fig. 16

Fig. 17

Figure 18. View showing 500 mountain pine beetle larvae and pupae mixed placed in duff consisting of white pine needles and decaying vegetation.
This section of duff was covered with a small piece of white pine bark.

Figure 19. View of duff shown in Figure 18 after a shrew (Sorex obscurus obscurus) had devoured the mountain pine beetle brood. The small holes are characteristic of this shrew's method of working in the duff that was covered with pieces of bark.

Figure 18. View showing 500 mountain pine beetle larvae and pupae mixed placed in duff consisting of white pine needles and decaying vegetation.
This section of duff was covered with a small piece of white pine bark.

Figure 19. View of duff shown in Figure 18 after a shrew (Sorex cinereus cinereus) had devoured the mountain pine beetle brood. The small holes are characteristic of this shrew's method of working in the duff that was covered with pieces of bark.

H.M.R.

Fig. 18

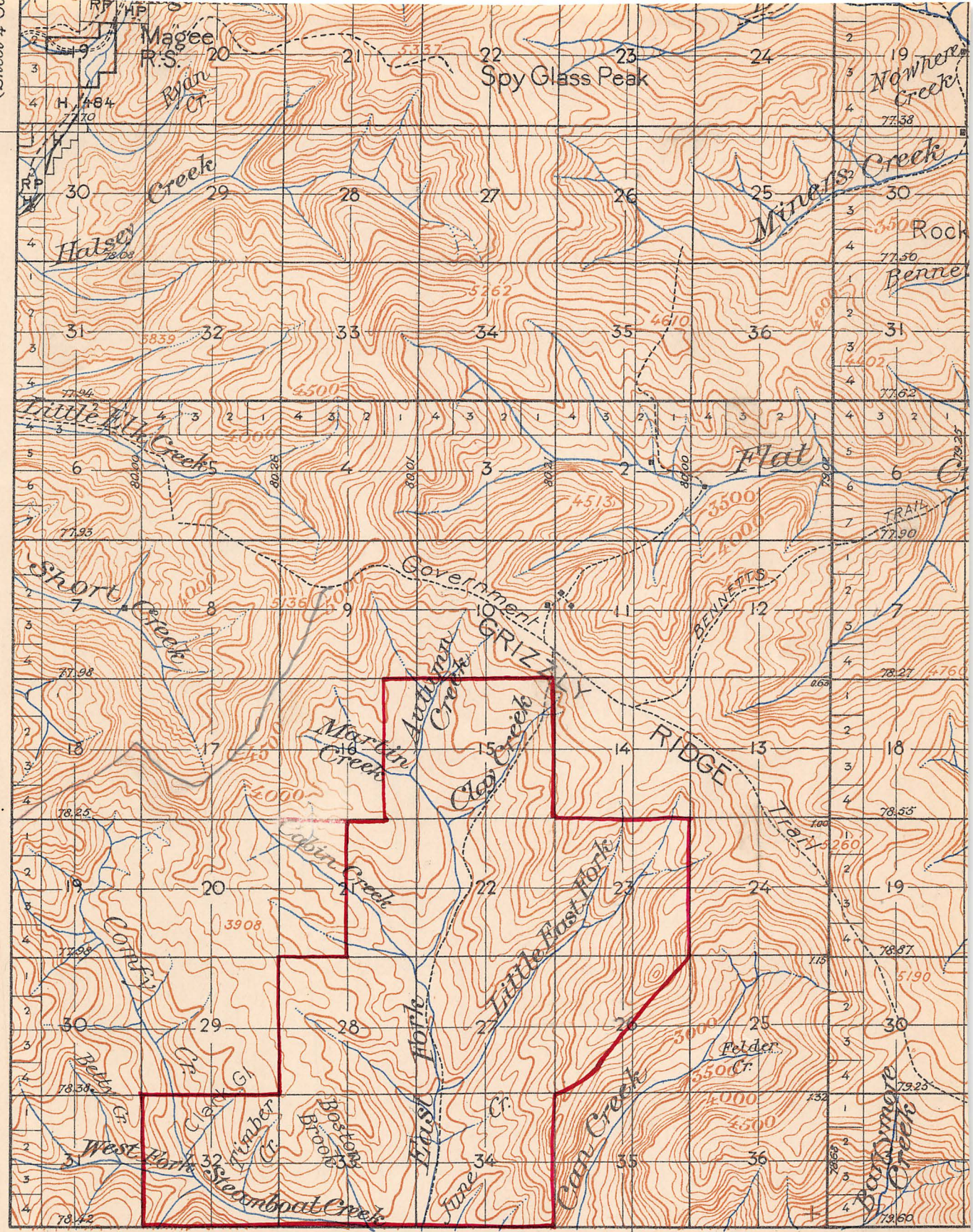
H.M.R.

Fig. 19

Figure 20. Adult wood mouse (Peromyscus maniculatus artemisiae) captured alive on Plot A, and used in feeding experiment given under Table 10.
Five hundred D. monticolae larvae and pupae mixed are shown in the pile on the center of a piece of white pine bark which shows the egg galleries, larval mines and pupal cells of the mountain pine beetle.

H.A.R.

Fig. 20



Compiled at District Office, Missoula, July, 1917,
from U. S. G. S., G. L. O., Forest Service, and
other surveys
by F. E. Bonner, C. F. Farmer, and J. B. Taylor
Traced by N. Knightlie

Boundary of 1929 Control Project
Steamboat Creek Drainage.

SCALE

1 ½ 0 1

Contour interval 100 feet